ASPECTS OF THE SEEDLING DEVELOPMENT OF LUCERNE *(Medicago sativa L.)*

I.D. BLAIR
AGRICULTURAL MICROBIOLOGY DEPARTMENT
LINCOLN COLLEGE

SUMMARY

Seedling emergence in typical lucerne fields may range from 0-150 plants / m row length. Comment is made on the relationship to seedling population of germination deficiency of seed and of pre-emergence decay arising from Fusarium soil fungi. After two months growth wide disparity of seedling vigour, measured by height of growth, was apparent. A specific root invading disease caused by species of Fusarium was partly responsible. Rhizobium nodulution was also absent among many seedlings. Data are presented confirming widely occurring failure of nodulation, and it is postulated that nodulation occurs at a low level of efficiency in typical fields, largely through failure to obtain levels of soil pH optimum for Rhizobium development.

INTRODUCTION

In this paper comment is made on aspects of plant population in lucerne fields that appear to be allied to thrift and development, based on inspection of somewhat above 500 lucerne crops throughout the South Island during the past five summers.

INITIAL ESTABLISHMENT

This can be expected to be linked with rate of seed sowing and germination capacity and vigour of such seed. Seed rates adopted certainly depict the divergence of opinion among farmers and their advisers, as to what rate of seeding is required to give an adequate seedling emergence. The range of seed sowing appears to be 9-22 kg/ha . The average rate would be 11-13 kg/ha. The relationship of this to seedling emergence is not clear although we expect a heavy seed rate to provide a relatively dense establishment notwithstanding irregular distribution in drill rows.

Forty years ago Doughty and Engledow (1928) concluded that the prime cause of fluctuation in their measured plant population densities (wheat fields) was irregularity of sowing by the farm drill. The continued inability of agronomists and engineers to resolve this problem is surprising, freely admitted and observed as the irregularity of plant cover when examined at the stage of seedling emergence. In counts of newly emerged seedlings made in drill rows the following appear to be typical. (Sowing, October 1969).

TABLE 1: Seedling Populations in Four Lucerne Sowings*

Field	Sowing Rate lb/ac.	kg/ha	Seedling Emergence*	Interquartile Range	Spread
1	9	10	6-22	11-16	5
2	10	11	0-30	2-10	8
3	14	15	0-46	7-14	7
4	20	22		10-29	19

*100, 0.33metre length drill row units examined and counted, 6-8 weeks after seed sowing.

Lack of assurance on the optimum seeding rate is in part based on a belief that there is a tendency of lucerne seed in New Zealand to have low germination. The following figures provided by Mr A.V. Lithgow, Superintendent, Seed Industry, Department of Agriculture, seem to support this impression. In 79 germination tests of lucerne seed at the Seed Testing Station the following results were obtained:

TABLE 2: Final Percentage Germination.

	Up to 10	11-20	21-30	31-40	41-50
% of samples	26	28	30	13	3
	51-60	61-70	71-80	81-90	
% of samples	19	38	25	15	

According to Mr Lithgow the occurrence of hard seed in individual samples is variable, averaging 15-25%, but with a range from single figures up to 40%. Hard seed is viable and may produce seedlings, but it is believed only a small proportion of this becomes established (Zaleski, 1957).

Whatever the germination capacity of lucerne seed is in laboratory testing, and the above comment implies that it is often inferior, this state appears to be worsened through pre-emergence decay and seedling mortality after sowing. It has been demonstrated in many soils in situations comparable to the South Island that establishment of lucerne seedlings is often extremely poor. Athow (1957) tested 64 lots of lucerne seed in Indiana, U.S.A., and recorded percent establishment only between 36-59. Even with seed of high laboratory germination (above 90%) field emergence did not exceed 50%. Similar results were reported by Tyler et.al., (1956) in New York state. In Zaleski's (1957) experiments in England field establishment did not exceed 64%. I can not locate New Zealand records on lucerne field emergence. It will certainly vary in a range of soil conditions. Simply to define the condition, two lines of certified Wairau seed, laboratory germination 63 and 70% were sown in mid-September 1969 in field soil prepared for lucerne sowing at Springston, Canterbury. One month later the field emergence of established seedlings from these two lines was 48% and 54%, in what appeared to be a well-prepared seed bed of favourable tilth and moisture content - a margin of difference depicting substantial loss.

It is also postulated that a soil disease factor identified with pathogenic fungi contributes significantly to irregular seedling establishment. We have demonstrated pathogenicity of the fungi *Fusarium avenaceum*, *Fusarium oxysporum* and *Fusarium oxysporum* var *redolens*. These species can be readily isolated from roots of young lucerne seedlings. Sanderson (pers. comm.) showed that cultures of *Fusarium avenaceum* produced 70% mortality of inoculated seedlings - a level of effect which has been exceeded with the Fusarium we have tested.

Pre-emergence loss and seedling damping off induced by micro-organisms is not unusual. It was reported in wheat in New Zealand by Blair (1938), in peas (Blair and Copp, 1953) and lucerne by Jacks (1956). The point being made at this stage is that *Fusarium* fungi cause substantial failure of seedlings to emerge. They also impair vigour of established seedlings, through various degrees of root injury.

Other contributory factors, additional to the relatively poor germination propensity of lucerne seed and *Fusarium* decay, have been examined by Triplett and Tisar (1960) including the influence of soil compaction, depth of sowing and moisture.

These contingencies of germination loss have induced some farmers to sow heavily and expensively (Table 1). The figures in that table indicate that a high rate of seeding certainly achieved a higher initial plant density but not necessarily a density that is uniform. The lower rate of seeding in fact achieved a more even distribution of seedlings. This was achieved by working the seed drill equipment at the minimum speed of movement. If this is so then the lower seed rate 9kg/ha succeeded with greater accuracy in providing the initial plant cover that surmounted the hazards of pre-emergence loss. Mr Palmer will comment on his experiments which have shown that (D.S.I.R. Ann. Rept. 1970, p.19) a lucerne plant spacing of 9cm or less within 18cm rows gave maximum production. He reported that if all the seed sown at 2.3 kg/ha had survived this low rate of seeding would be adequate. In the C.R.D. trials 5.5 kg/ha seeding was as good as 11-16 kg/ha.

Zaleski (1957) also concluded that with heavy loss of seedling plants as between sowings of 16 kg and 5.5 kg/ha, 83% of plants did not survive the first year in a dense crop. He concluded that the view that high seed rates were a safeguard against failureto establish were without foundation. The upper levels of seedling density are certainly incompatible with final establishment as adult plants. It is very difficult to determine what an optimum adult plant establishment might be because of the massiveness of lucerne crown development, depth of rooting and interlacing of stems. In my limited attempt to count the distribution of adult plants I concluded that 10-13 plants per metre was indicative of satisfactory density. Stem tillering from this number of plants seems to provide adequate cover.

VIGOUR OF ESTABLISHED SEEDLINGS

A striking aspect that must impress an observer in the field is the disparity of plant vigour within a seedling population. At two months of growth it is customary to find seedlings ranging from 24 cm high and tillering, to others less than 8 cm.

The view generally held is that these disparities in height and vigour may be the consequence of an interaction among the factors of -

Seedling competition,
Delayed germination derived from hard seeds,
Action of various insect pests and diseases at the seedling stage, e.g. Springtails.
Failure of *Rhizobium* nodulation.

Zaleski's (1957,1959) work is the only information that I am acquanted with that has measured the competitive effect among lucerne seedlings. It is to be noted, however, that in obtaining the measurements of seedling height (Figures 1 and 2) the abnormally small seedlings appeared to be located within the drill rows, as frequently in positions of isolation away from other plants, as in the situations of plant crowding. Some proportion of these small seedlings can be expected to be derived from delayed germination of hard seeds.

In other instances these stunted seedlings have roots that show signs of fungus injury - brown lesions and die-back of root terminals. From these lesions *Fusarium* fungi are consistently isolated. Inoculation experiments have shown that whereas many of these fungi readily produce pre-emergence decay and seedling damping-off, others in less virulent form perhaps or through infection being delayed until after seedling establishment, appear to damage the roots and consequently impair seedling growth.

SEEDLING VIGOUR AND RHIZOBIUM NODULATION

Dealing with last summer's inspections only, I examined 119 new sowings of lucerne from North Canterbury to North Otago, all drilled October and November, and I now record in Table 3, the extent of Rhizobium nodulation of these crops.

TABLE 3: Rhizobium Nodulation

Good	7-9/10	plants nodulated	16%
Fair	4-6/10	" "	17%
Poor	1-3/10	" "	42%
Nil			23%

The crops were all examined at comparable stages of seedling growth, at least 6-8 weeks after sowing and at which stage of growth it is known that nodules are observable provided the inoculation has been effective. Throughout the area, soil and growing conditions in October-November 1970 were very favourable, having been preceded by adequate rainfall and mild temperatures.

During the October-December period of last year, newly-sown lucerne in Canterbury certainly had a good start. The vigour of seedlings was noticeably good. The absence of nodules in so many field samples was all the more surprising, particularly in view of our ease of achieving Rhizobium nodulation in pure culture assemblies.

The first reaction when nodulation fails is that the Rhizobium culture available for use have been deficient. The use and development of inoculation was reviewed recently (Blair, 1971) and it was concluded that those at present in use are satisfactory at the point of manufacture. It does not seem possible at this juncture for any authority to devise a testing service that will indicate the population level and state of viability of the nitrogen-fixing bacteria at the actual date of sowing on the farm.

A fact of primary importance, is the population or numbers of rhizobia on the seed at the time it is germinating. In this study one factor only of the several that may function, soil pH, has been recorded - the Universal Indicator test. It served to give a general indication of the position. It was also possible to occasionally check the result obtained with the Universal Indicator against official tests (Department of Agriculture) from which comparison it was concluded that the field test was satisfactory within limits of 0.5 points. Results obtained are shown in Table 4.

TABLE 4: Nodulation at the Seedling Stage and Soil pH

pH at 1" level	Good	Fair	Poor	Nil
		No. of Crops		
Below 5.0	-	-	-	-
5.0 - 5.5	-	-	10	16
5.5 - 6.0	-	2	28	4
6.0 - 6.5	10	8	12	5
6.5 - 7.0	10	11	-	3
Totals -	20	21	50	28
Percent -	16%	17%	42%	23%

From Table 4 it can be seen that the 16% and 17% respectively of Good - Fair nodulation were with two exceptions, in soil at pH 6.0 - 6.5 or higher. In the Poor - Nil category of nodulation almost 74% of the crops occurred in soil at pH below 6.0.

There were, however, eight crops (6%) in the Nil nodulation category that were in soil of pH in the vicinity of 6.5. This failure of nodulation at what is regarded as near optimum pH must be attributed to other physical causes that impair bacterial survival.

Overall, it is clear that a substantial amount of nodulation failure can be linked with low pH of soil at the time of sowing. Some farmers seem to have forgotten or have ignored the proven lessons of the essentiality of adequate liming in preparation for lucerne. If they have not actually forgotten, their decision to cut costs by reducing expenditure on lime appears to be unsound when this economy decision may be at the expense of thrift in lucerne. It has been assumed from our conventional thinking on the subject that non-nodulated lucerne does not thrive and it clearly does not thrive on some soil types. Without exception in the seedlings inspected and lifted in this past summer, lucerne growth was regarded as satisfactory - mostly very good. It was obvious that the seedlings in most cases were deriving nitrogen from other than the symbiotic source, the Rhizobium/plant association. In general the amount of nodule tissue per plant was small and our category of good nodulation (Table 2) is simply a high percentage of plants with nodules evident. Only one seedling crop in 119 was found with nodules present in any impressive density, comparable with what we can obtain pure culture assemblies.

I have concluded that nodulation of lucerne, in theory essential because of the free fixation of N, in fact occurs at a low level of efficiency under field conditions. Early growth of lucerne would seem to be dependent on a level of nitrogen available in soil at the time of sowing. In this regard it was noted that 71% of the 119 new sowings had been placed after turnips or other winter feed, heavily stocked. It is suggested that mineralised nitrogen from this organic source has provided the initial nitrogen requirements, aided by the use of dormant lucerne in winter as run-off or holding paddocks for feeding cut hay to the concentrated sheep flock. These sources to my way of thinking now appear to be the ones that supply lucerne with nitrogen, more so than the Rhizobium - plant symbiosis.

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